Autonomous Operation for Last-Mile Food, Grocery, and Goods Delivery on an Urban Sidewalk

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Abstract

The purpose of the project is to simulate successful autonomous navigation of a delivery robot along sidewalks in a busy urban environment from store to delivery address on ground level.

Introduction

Last mile delivery has been a growing issue with the increase in e-commerce over at least the last 8 years with each year growing from 15-30% from the year before [1]. Since much of this final delivery is accomplished via vehicles, the has been an accompanying call for reduced emissions. A McKinsey study estimates that this could lead to a 25% increase in CO2 emission in cities [2]. Most recently, the COVID pandemic with its isolation mandates have led to even greater demand for delivery of not only goods but also everyday essentials such as meals, groceries, and prescription medicine. This needed to be accomplished with minimal human contact while fewer humans were available due to quarantines and employee availability. For grocery delivery, the need for fastest route planning is also necessary due to the presence of perishables and temperature sensitive cargo - or, in other words, people prefer their meals hot and their frozen goods cold. Cheng et al [4] have shown efficient curb detection to set the limits of the robot's path.

Goals

Our goal is to create planning and execution algorithms to permit autonomous navigation and avoidance of both static (mailboxes, trashcans, signs)and dynamic obstacles (people, cars) while following sidewalk rules (crosswalks etc).

Proposed Methods

We plan to explore various navigation, collision detection and avoidance methods implemented in Python to successfully navigate around static obstacles, avoid dynamic obstacles and reach the destination in a simulated urban environment in Gazebo.

Expected Results

We expect to create a Gazebo-based simulation to navigate from the store to a nearby, ground level delivery address via sidewalks. Along the way, we plan to encounter static obstacles such as fire hydrants, garbage cans and mailboxes. We also expect to encounter moving obstacles like people, cars, or other robots. Through this we will avoid collisions to arrive at the delivery destination while following sidewalk rules.

Proposed Schedule

We propose development along the following schedule:

Milestone	Date
Proposal	Feb 1
Gazebo learning	Feb 1-18
Status Update	Feb 21
Sample environment	Feb 28
Planning algorithm	Mar 14
Obstacle avoidance algorithms	Apr 11
Final Writeup and Presentation	Apr 25-29
Final Submission	May 2

Division of Labor

We plan extensive and equal collaboration on all aspects of the project to include coding, algorithm development, testing and submissions. Further delineation of work may occur as we determine proficiency in certain aspects of the project.

References

[1] https://www.statista.com/statistics/379046/worldwide-retail-e-commerce-sales/

[2] https://www.mckinsey.com/industries/travel-logistics-and-infrastructure/our-insights/efficient-and-sustainable-last-mile-logistics-lessons-from-japan

[3] M. Kocsis, J. Buyer, N. Sußmann, R. Zöllner and G. Mogan, "Autonomous Grocery Delivery Service in Urban Areas," 2017 IEEE 19th International Conference on High Performance Computing and Communications; IEEE 15th International Conference on Smart City; IEEE 3rd International Conference on Data Science and Systems (HPCC/SmartCity/DSS), 2017, pp. 186-191, doi: 10.1109/HPCC-SmartCity-DSS.2017.24.

[4] M. Cheng, Y. Zhang, Y. Su, J. M. Alvarez and H. Kong, "Curb Detection for Road and Sidewalk Detection," in IEEE Transactions on Vehicular Technology, vol. 67, no. 11, pp. 10330-10342, Nov. 2018, doi: 10.1109/TVT.2018.2865836.

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